

What is claimed is:

1. A fatigue-level estimation apparatus comprising:
a heart rate calculator configured to receive a signal indicative of
a heartbeat of an object to be estimated to calculate a heart rate signal
5 changing sequentially in time; and
a fatigue level estimator configured to estimate a fatigue level of
the object by detecting a sharp and transient rise in the heartbeat in the
heart rate signal calculated by the heart rate calculator.
- 10 2. The fatigue-level estimation apparatus according to claim 1,
further comprising an alarm unit configured to issue an alarm when the
fatigue level of the object estimated by the fatigue level estimator
becomes larger than a predetermined value.
- 15 3. The fatigue-level estimation apparatus according to claim 1,
further comprising a display unit configured to display pieces of
information in relation to the fatigue level of the object estimated by the
fatigue level estimator.
- 20 4. The fatigue-level estimation apparatus according to claim 1,
wherein the fatigue level estimator comprises
an average heart-rate calculating unit configured to calculate an
average heart rate over a specified period of time on the basis of the
heart rate signal;
25 a first elapsed-time measuring unit configured to measure an
elapsed time during which the heart rate signal is over the average
heart rate;
a second elapsed-time measuring unit configured to measure an
elapsed time during which the heart rate signal is below the average
30 heart rate; and
a comparison output unit configured to draw a comparison
between the elapsed times measured by the first and second
elapsed-time measuring units to output information indicative of the
fatigue level.
- 35 5. The fatigue-level estimation apparatus according to claim 4,

further comprising an alarm unit configured to issue an alarm when the fatigue level of the object estimated by the fatigue level estimator becomes larger than a predetermined value.

5 6. The fatigue-level estimation apparatus according to claim 4, further comprising a display unit configured to display pieces of information in relation to the fatigue level of the object estimated by the fatigue level estimator.

10 7. The fatigue-level estimation apparatus according to claim 1, wherein the fatigue level estimator comprises

 an average heart-rate calculating unit configured to calculate an average heart rate over a specified period of time on the basis of the heart rate signal;

15 a first variance-value calculating unit configured to calculate a variance-value in a temporal range during which the heart rate signal is over the average heart rate;

 a second variance-value calculating unit configured to calculate a variance-value in a temporal range during which the heart rate signal
20 is below the average heart rate; and

 a comparison output unit configured to draw a comparison between the variance-values calculated by the first and second variance-value calculating units to output information indicative of the fatigue level.

25 8. The fatigue-level estimation apparatus according to claim 7, further comprising an alarm unit configured to issue an alarm when the fatigue level of the object estimated by the fatigue level estimator becomes larger than a predetermined value.

30 9. The fatigue-level estimation apparatus according to claim 7, further comprising a display unit configured to display pieces of information in relation to the fatigue level of the object estimated by the fatigue level estimator.

35 10. A fatigue-level estimation apparatus comprising:

a peak-to-peak interval calculator configured to detect a peak value in a predetermined measurement range of a signal indicative of a heartbeat of an object to be estimated and to calculate a peak-to-peak interval from the peak value; and

5 a fatigue level estimator configured to measure an average value of the peak-to-peak interval calculated by the peak-to-peak interval calculator and to draw a comparison between an amplitude over the average value and a further amplitude over the average value for estimating a fatigue level of the object.

10 11. A fatigue-level estimation method comprising the steps of:
receiving a signal indicative of a heartbeat of an object to be estimated to calculate a heart rate signal changing sequentially in time; and

15 estimating a fatigue level of the object by detecting a sharp and transient rise in the heartbeat in the calculated heart rate signal.

12. The fatigue-level estimation method according to claim 11, wherein the fatigue level estimating step comprises the sub-steps of:

20 calculating an average heart rate over a specified period of time on the basis of the heart rate signal;

first measuring an elapsed time during which the heart rate signal is over the average heart rate;

25 second measuring an elapsed time during which the heart rate signal is below the average heart rate;

drawing a comparison between the measured elapsed times to output information indicative of the fatigue level.

13. The fatigue-level estimation method according to claim 11, wherein the fatigue level estimating step comprises the sub-steps of:

30 calculating an average heart rate over a specified period of time on the basis of the heart rate signal;

first calculating a variance-value in a temporal range during which the heart rate signal is over the average heart rate;

35 second calculating a variance-value in a temporal range during which the heart rate signal is below the average heart rate; and

drawing a comparison between the calculated variance-values to output information indicative of the fatigue level.

14. A fatigue-level estimation method comprising the steps of:
5 detecting a peak value in a predetermined measurement range of a signal indicative of a heartbeat of an object to be estimated;
calculating a peak-to-peak interval from the peak value;
measuring an average value of the peak-to-peak interval
calculated by the peak-to-peak interval calculator; and
10 drawing a comparison between an amplitude over the average value and a further amplitude over the average value for estimating a fatigue level of the object.

15. The fatigue-level estimation method according to claim 11,
15 further comprising the step of issuing an alarm when the estimated fatigue level of the object becomes larger than a predetermined value.

16. The fatigue-level estimation method according to claim 11,
further comprising the step of displaying pieces of information in
20 relation to the estimated fatigue level of the object.

17. A computer-readable program for estimating a fatigue level, the program being executed by a computer provided in a fatigue-level estimation apparatus, the computer achieving the functions of:

25 heart rate calculating means for receiving a signal indicative of a heartbeat of an object to be estimated to calculate a heart rate signal changing sequentially in time; and

fatigue level estimating means for estimating a fatigue level of the object by detecting a sharp and transient rise in the heart rate in
30 the heartbeat signal calculated by the heart rate calculating means.

18. The program according to claim 17, wherein the fatigue level estimating means comprises:

calculating means for calculating an average heart rate over a
35 specified period of time on the basis of the heart rate signal;

first measuring means for measuring an elapsed time during

which the heart rate signal is over the average heart rate;

second measuring means for measuring an elapsed time during which the heart rate signal is below the average heart rate;

comparing means for drawing a comparison between the
5 measured elapsed times to output information indicative of the fatigue level.

19. The program according to claim 17, wherein the fatigue level estimating means comprises:

10 calculating means for calculating an average heart rate over a specified period of time on the basis of the heart rate signal;

first calculating means for calculating a variance-value in a temporal range during which the heart rate signal is over the average heart rate;

15 second calculating means for calculating a variance-value in a temporal range during which the heart rate signal is below the average heart rate; and

comparing means for drawing a comparison between the calculated variance-values to output information indicative of the
20 fatigue level.

20. A computer-readable program for estimating a fatigue level, the program being executed by a computer provided in a fatigue-level estimation apparatus, the computer achieving the functions of:

25 detecting a peak value in a predetermined measurement range of a signal indicative of a heartbeat of an object to be estimate;

calculating a peak-to-peak interval from the peak value;

measuring an average value of the peak-to-peak interval calculated by the peak-to-peak interval calculator; and

30 drawing a comparison between an amplitude over the average value and a further amplitude over the average value for estimating a fatigue level of the object.